EFFECTS OF FALLOW MANAGEMENT AND CROPPING SEQUENCES ON PRODUCTION AND RESIDUAL N UPTAKE IN WHEAT

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Summary. Control of summer growing grasses with glyphosate in wheat fallow for only five weeks substantially increased yield and N uptake on both a black earth and a red-brown earth, due to moisture conservation in 1994, an extremely dry year. There were yield and N uptake responses to residual N from applications of 120 kg/ha for grain legume, long fallow and continuous wheat rotations, but not for lucerne, clover and medic rotations on both soils. The lack of response to residual N in wheat following pasture legume rotations was due to increased crop growth from better N fertility, which exhausted the limited soil water.

INTRODUCTION

Large and widespread wheat yield responses to nitrogen (N) fertiliser have been reported from trials in northern NSW (7), the most profitable N rate being 60 kg/ha or more in over half of these experiments (2). However, there is still a reluctance by farmers to apply rates over 20-30 kg/ha due to the variability of the climate and the fear that if the season turned dry the N fertiliser investment would be lost. Recent results (1, 9) showed that there can be substantial carryover of unused fertiliser N on wheat, in the second and even the third year after application. The aim was to examine the effect of summer grass control on yield and grain N uptake in wheat. This paper reports grain yields, protein and N uptake data for the 1994 wheat crop.

MATERIALS AND METHODS

Long-term trials were established on a red-brown earth and an adjoining black earth in 1966 to examine the effects of crop rotations on the sustainability of wheat production. The first two phases of the experiments have been reported (5, 6).

The third phase of these experiments started in 1988 and consisted of the following treatments:

1. Sub clover from 1988-90, wheat from 1991-94

2. Lucerne from 1988-90, wheat from 1991-94

3. Snail medic from 1988-90, wheat from 1991-94

4. Chickpeas (CP) in 1988, then wheat (W)-CP-W-CP-W-W

5. Long fallow (LF, 18 months) in 1988, then wheat-LF-W-LF-W-W

6. Continuous wheat from 1988-94.

Both experiments are arranged in a 6x6 Latin square design. Plots are 27x15 m on the red soil and 31x11 m on the black soil. These plots are sub divided for rates of N but only the nil and 120 kg N/ha rates are reported here. Nitrogen was applied as urea (46% N) in 1991 and 1993 to sub-plots of all treatments and in 1992 to sub-plots of continuous wheat by combine at sowing.

Rainfall of 139 mm in December-January 1993/94 caused growth of liverseed *(Urochloa panicoides),* barnyard *(Echinochloa crus-galli)* and crab grass *(Eleusine indica).* One of the nil N sub-plots was

sprayed out on the 18 January with glyphosate while the grass was left to grow on all other plots until they were all cultivated at the end of February.

Soil moisture was measured to a depth of 1.5 metres in April 1994. Wheat, without N was grown on all plots in 1994 to measure residual effects of previous treatments. Plots were sown on the 15 June and harvested on the red soil on 23 November and black soil on 4 December 1994. Grain samples were analysed for protein using the NIR method.

RESULTS AND DISCUSSION

1993

Above average rainfall (356 mm) from June to November, 1993 gave good yields on the black soil, from 1.03-3.35 tonnes/ha without N fertiliser to 4.31-5.94 t/ha with 120 kg N/ha. This represented apparent recoveries of 28-43% of the N applied that year. On the red soil, 1993 yields ranged from 0.76-2.47 t/ha without N fertiliser, to 3.76-4.16 t/ha with 120 kg N/ha, an apparent recovery of 32-46%. These recoveries are similar to those recorded in the region where marked grain yield responses to N occurred (3).

Black Earth

Because 1994 was extremely dry, with only 125 mm received during crop growth compared to 300 mm average, yields were low ranging from only 420-600 kg/ha without N, to 440-720 kg/ha with residual N on the black soil (Table 1). However, where grass was sprayed out yields ranged from 800 kg/ha for the continuous wheat rotation to 1020 kg/ha for the clover rotation. Spraying out grasses increased yields over unsprayed plots for all rotations. Controlling grasses also gave higher yields than where 120 kg N/ha had been applied the previous year for all rotations, but increases were not significant for long fallow and continuous wheat rotations. This indicates that controlling grasses increased soil water and that the N input by the legume rotations was sufficient to enable wheat to respond to the additional water available, whilst N supply limited the response to spraying on the two non legume rotations. Spraying increased available water an average of 7 mm in the top 30 cm, and this was critical in this extremely dry year.

Nitrogen uptake was significantly increased by controlling grass in all rotations and this was due entirely to yield increase as protein levels were maintained or decreased in all rotations as a result of the dilution effect. Spraying out grass in January gave significantly higher N uptake than residual fertiliser N for the three pasture legumes. This shows that the main effect of weed control was on water conservation, as these are the rotations which had the highest N input (4).

In the absence of previously applied N, wheat yields were greater on the clover than on the grain legume rotation plots. There was a significant yield response to residual fertiliser N in the grain legume, long fallow and continuous wheat rotations which indicates N deficiency as a limiting factor in these plots. Residual fertiliser N depressed yield in the lucerne and clover rotations, such that all rotations except clover outyielded the lucerne rotation. This is assumed to be due to depletion of soil moisture by increased vegetative growth as measurement of available soil moisture in April 1994 confirmed that the three highest grain yields were produced from plots with the highest levels of available moisture. The three pasture legume rotations had the highest vegetative yields, but the three lowest grain yields. Thus in the absence of N fertiliser, N was a major limiting factor on grain legume, fallow and wheat rotations, while water was the main limiting factor for the pasture legume rotations.

Table 1. Wheat grain yield, protein and N uptake from a red and black soil in 1994.

		Red-brown earth			Black earth		
Rotation	1993 N	Yield	Prot.	Uptake	Yield	Prot.	Uptake

	Rate/ha	(kg/ha)	(%)	(kg/ha)	(kg/ha)	(%)	(kg/ha)
Clover	Nil *	600	11.8	12.2	604	13.0	13.4
	Sprayed	862	11.9	17.5	1024	12.5	21.5
	120 kg	615	13.0	13.6	584	14.5	14.6
Lucerne	Nil	600	12.3	12.8	498	14.3	12.2
	Sprayed	900	12.9	20.2	813	13.4	18.7
	120 kg	480	14.6	12.1	440	15.4	11.5
Medic	Nil	510	11.0	9.6	480	11.8	9.7
	Sprayed	820	10.6	15.0	920	11.5	18.3
	120 kg	570	12.4	12.2	620	13.6	14.6
Grain	Nil	490	10.1	8.6	420	10.0	7.4
Legume	Sprayed	820	10.1	14.5	850	10.0	14.4
	120 kg	680	10.5	12.6	680	11.1	12.6
Long	Nil	340	9.3	5.6	520	9.3	8.5
Fallow	Sprayed	470	9.4	7.5	860	9.0	13.7
	120 kg	550	9.6	9.3	720	9.7	12.2
Annual	Nil	300	10.0	5.2	440	9.7	7.4
Wheat	Sprayed	440	10.2	7.7	800	9.7	13.4
	120 kg	510	10.5	9.2	700	10.3	12.4
s.e.d.	a.	89	0.47	1.68	74	0.37	1.37
	b.	111	0.55	2.1	87	0.46	1.68

* Nil = No N applied and unsprayed, Sprayed = No N but sprayed, 120 kg = 120 kg N/ha in 1993 and unsprayed.
a. Within rotations; b. Across rotations.

In the absence of N fertiliser, N fixation from the clover and lucerne rotations gave significantly greater N uptake than grain legume, long fallow and continuous wheat rotations. Protein levels were no greater than 10% for the latter three rotations, showing that N was severely deficient. Although residual N fertiliser did increase protein levels for all rotations, N uptake for the clover and lucerne rotations, was not significantly increased because of lower yields. Nitrogen uptake in all other rotations was increased due to significant yield or protein increases from residual N fertiliser. The four legume rotations increased protein by 1.1-1.8 percentage points and this effect of residual N fertiliser has been previously reported (1, 4, 9).

Red-brown earth

The highest yields on this soil also occurred where grasses were sprayed out, being significantly higher than unsprayed for all legume rotations, and residual fertiliser N for all pasture legume rotations. Spraying also increased yields over the unsprayed plots for the long fallow and continuous wheat rotations, but the

highest yields in these rotations occurred with residual N, indicating a N deficiency. Spraying significantly increased N uptake over the residual fertiliser N treatment, only for the lucerne rotation. In all other rotations N uptake was directly related to yield increases, as spraying had little effect on protein levels.

The three pasture legume rotations gave the highest protein levels without fertiliser N, but also gave the largest response to residual N, increasing protein by 1.2-2.3 percentage points to a minimum of 12.4%. Nitrogen should not be limiting yield at these levels (8) and confirms water as the main limiting factor for these three rotations. Again the long fallow and continuous wheat rotations, along with the grain legume rotation on this soil, had the lowest protein levels which did not respond significantly to grass control or residual N fertiliser, even though all contained as much available water as the pasture legume rotations.

Nitrogen uptake from clover and lucerne rotations were significantly higher than from long fallow and continuous wheat rotations in the absence of applied N, from increases in both yield and protein. Residual fertiliser N had no effect or slightly depressed grain N uptake from the pasture legumes rotation plots, but significantly increased uptake from the grain legume, long fallow and continuous wheat rotations. This reflected the previous contribution of N from the legume rotations (4).

CONCLUSIONS

Nitrogen uptake from wheat was increased by controlling summer grass growth for a five week period for all six rotations on a black earth and a red-brown earth at Tamworth in 1994. This effect was due to increases in available soil water increasing yields in this dry year. Residual fertiliser N did not significantly increase grain N uptake for the lucerne and clover rotations on either soil or medic rotation on the red soil. However, residual N did increase N uptake for grain legume, long fallow and continuous wheat rotations on both soils, alleviating N deficiency in these rotations. Residual fertiliser N on the non pasture legume rotations increased grain N uptake by up to 5 kg/ha an increase of over 70%, while controlling grass increased uptake on all rotations, increasing uptake by over 8 kg/ha an increase of up to 95%, a large benefit in this dry year.

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